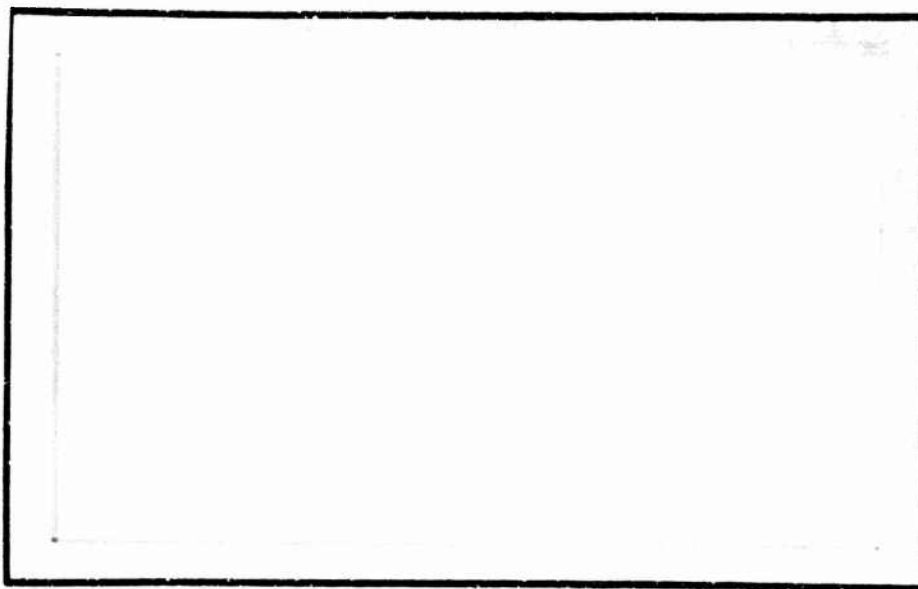


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13. ABSTRACT A triaxial accelerometer system was developed for flight on the Cannon Ball II satellite (OAR 901). This report provides the necessary operating and diagnostic instructions for this research equipment. Included are operation and calibration instructions, interconnection diagrams, logic diagrams, schematics and assembly drawings.		
KEYWORDS: Accelerometer, Acceleration, Triaxial accelerometer,		

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REPORT NO. 6098-954002

R & D EQUIPMENT INFORMATION REPORT

3 AXIS ACCELEROMETER (MESA)

FOR

CANNONBALL II

June 15, 1971

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CODE IDENTIFICATION 80070

<u>W. B. Lunge</u>	<u>6/15/71</u>	_____	_____
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I. PURPOSE OF EQUIPMENT

The triaxial accelerometer is intended to measure extremely small forces along three mutually perpendicular axes when mounted in the Cannonball II satellite. Each axis will sense in two directions, normally referred to as plus and minus accelerations. The output signal from each axis is presented in both analog and digital form.

II. THEORY OF OPERATION

The tri-axial accelerometer for the Cannonball II satellite is identified as Bell Aerospace Company (BAC) part number 6176-300001.

In order to identify each component and its interconnections, reference should be made to BAC Drawing number 6176-300001. This drawing shows that each system is made up of 5 units and 6 interconnecting cables. The parts list identifies each piece by part number and title. All BAC drawings appearing on this parts list are included in the drawing folder.

The direction of the three axes are marked on the outside of the instrument package. Motion of the case along any one of these axis will cause the output signal to appear. Since these accelerometers are scaled to measure forces in the micro-g and milli-g region, they present special problems in handling and calibration when exposed to the one -g environment existing on the earth.

The nominal full scale ranges are listed below. Along with each is the maximum angle by which the sensitive axis may be tilted from horizontal without exceeding the range.

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	\pm Input g's	Tilt Angle
Range A	1.2×10^{-2}	41'-20"
Range B	$7 \times 10^{-4} g$	2'-25"
Range C	$1.6 \times 10^{-5} g$	3.3"

A glance at this list shows that even on the least sensitive scale (Range A) the sensitive axis must be horizontal to within $3/4$ degree in order to stay on scale.

The output of each channel is proportional to input acceleration and is available in both digital and analog form.

The analog output appears as a zero to 5 volt d-c signal. It derived from the digital signal and its magnitude is proportional to the pulse output rate representing input acceleration. The same pulse rate and d-c output represent full scale on each range.

Typical values are as shown below:

<u>Input Full Scale</u>	<u>Analog Output (Volts)</u>	<u>Digital Output Pulses/Second</u>
0	.15	0
20%	1.0	1000
40%	2.0	2000
60%	2.8	3000
80%	3.7	4000
100%	4.5	5000

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III. BENCH TESTS

Preliminary

Interconnect the system as shown on BAC drawing No. 6176-300001. Observe that power switches on the test set are in the following positions. Test set power - OFF, DC supply to - INT., System Power - OFF. Connect the test set power cord to any 115V - 60 cycle outlet. Disable channels X and Y by disconnecting both P3 (cable W2) plugs from the interface unit. Make sure that the 3 Axis instrument package is resting on a fairly stable flat surface and is level to within $\frac{1}{2}$ degree. Turn the test set power - ON, and observe the system voltage meter indicates approximately 28 volts dc, and system current is zero. Place all three meter switches on INT.

Z Channel Tests

Place Z channel meter switch in analog output position. Turn system power - ON and observe that system current meter reads about 0.2 amps. Place both cross axis and sensitive axis range T/M meter selector switches in their A positions. Depress and hold the suspension command switch for approximately $\frac{1}{2}$ second. Repeat until cross axis meter indicates about 40 micro amps (4 T/M volts). Depress and hold the sensitive axis command switch for approximately 1 second. Repeat until sensitive axis command meter indicates about 40 micro amps (4 T/M volts). Observe the Z channel float position meter while very gently tilting the Z axis back and forth through horizontal. The float position meter should follow by alternately going from 0 to 50 micro amps. This indicates proper suspension of the proof mass in the accelerometer. Rest the three axis package flat on the table and observe if analog output is less than 50 micro amps. If not, tilt

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Z axis and shim appropriate end to give an on scale reading. Very slight adjustments in the tilt should now cause the analog output to vary between 0 and 5VDC. Tilting the base to reduce the analog output will cause the float position meter to go to approximately 25 micro amps (2.5 T/M volts) when the analog output is minimum. This is the null or zero g input condition. As long as the analog output is less than 50 micro amps, the float position meter will indicate a fairly steady value of either 10 or 40 micro amps depending on the polarity of the input g's.

Switch the meter selector switch to ELECT. TEMP and note the reading. At room temperature this should indicate approximately 20 micro amps. (2 T/M volts). Switch the meter selector to ACCEL-TEMP. The reading should again be approximately 20 micro amps.

Overrange Circuit Test

Place the sensitive axis command meter in position B and depress the range command observing that meter reads about 40 micro amps. Tilt the sensitive axis to cause the analog output to saturate at 50 micro amps; this activates the overrange circuit. The analog output should now drop to near zero for about 20 seconds, then return momentarily (2 seconds) to 50 micro amps, and then back to near zero. Switch the command meter selector switch back to A and depress the sensitive axis command two times. The meter should again read 40 micro amps and the analog output should be near zero. This completes bench test of the Z channel. Turn system power - OFF and proceed to the Y channel tests.

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Y Channel Tests

Connect P3 (cable W2) to J3, channel Y, on the signal conditioner. Place Y channel meter switch in analog output position. Turn system power ON and observe that system current increases to about 0.4 amps. Note that both Sensitive Axis and Cross Axis command meters indicate about 40 micro amps corresponding to Range A. Observe the Y channel float position meter while gently tilting the Y axis back and forth through horizontal. The float position meter should follow by alternately going from 0 to 50 micro amps, indicating suspension of the Y accelerometer. Rest the three axis package flat on the table and observe if analog output is less than 50 micro amps. If not, tilt and shim appropriate mounting lug to obtain an on scale reading. The indications of float position and analog output should be the same as described for the Z channel. Check the Elect. and Accel. Temp readings by means of the selector switch. The readings should be approximately 20 micro amps at room temperature.

Overrange Circuit Test

Place the sensitive axis command meter in position B and depress the range command observing that meter reads about 40 micro amps. Tilt the sensitive axis to cause the analog output to saturate at 50 micro amps; this activates the overrange circuit. The analog output should now drop to near zero for about 20 seconds, then return momentarily (2 seconds) to 50 micro amps, and then back to near zero. Switch the command meter selector switch back to A and depress the sensitive axis command two times. The meter should again read 40 micro amps and the analog output should be near zero. This completes bench test of the Y channel. Turn system power - OFF and proceed to check the X channel.

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X Channel Tests

Connect P3 (cable W2) to J3 channel X on the signal conditioner. Place X channel meter switch in the analog output position. Turn system power - ON and observe that system current increases to about 0.6 amps. Note that both command indicators read about 40 micro amps corresponding to Range A. Observe the X channel float position meter while gently tilting the X axis back and forth through horizontal. Note that the 3 axis mount must be turned on its side in order to get the X axis horizontal. Continue tests on X channel as described for Y channel above. This completes the X channel tests. Turn system power - OFF and place the three axis package on its three mounting pads.

Command Tests

Turn system power - ON and observe that both command meters indicate about 40 micro amps (4 T/M volts = Range A). Depress the suspension command, hold for 1 second and release. The cross axis meter should go to about 2 micro amps (0 T/M volts). Switch the cross axis meter selector switch to B; meter should again read 40 micro amps. Depress sensitive axis command, hold for 1 second and release. The sensitive axis meter should go to about 2 micro amps (0 T/M volts). Switch sensitive axis meter selector switch to B; meter should again read 40 micro amps. Turn system power switch - OFF. Leave off for about 5 seconds. Turn system power - ON and note that both command meters read about 40 micro amps. Depress each switch, hold for 1 second and release. Switch both meter selectors to C range. Both meters should indicate about 40 micro amps. Turn system power - OFF for 5 seconds and then ON again. Command meters should again read about 40 micro amps. Depress each command switch, hold for 1 second and release. Both command meters should indicate about 20 micro amps (0 T/M volts). Switch both meter selectors to the A range. Both

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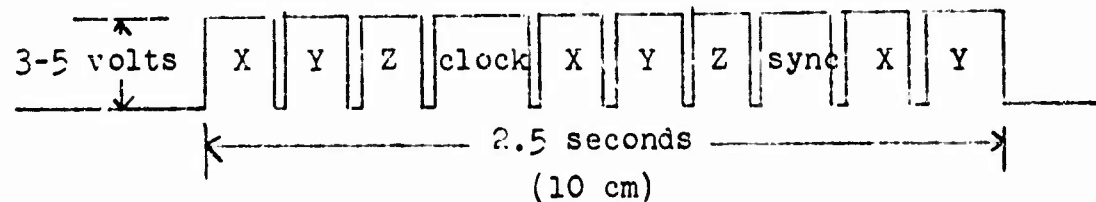
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should indicate 40 micro amps. This completes the command tests

Digital Signal Conditioner Tests

Connect an oscilloscope to either the bnc connector or the binding posts labeled "digital output." Set the scope time base to about 250 msec/cm (assuming a 10 cm viewing area). Sync the scope sweep generator and observe the presence of the channel words, sync word, and clock word as shown below. Note that the amplitude of the output pulse train is $+4 \pm 1$ volt.



IV. INSTALLATION TESTS

Install each of the five units which make up the system in their respective places in the satellite. Connect cables W1, and W2. Make sure that all units of a particular channel are mated to the connectors with that channel marking. Connect test cable to J5 on the interface unit. Temporarily disconnect P3 channels Y and Z. Connect the test set to 115V - 60 cycle power. Turn test set power - ON. Voltage should be 28V. Turn all meter switches to INT., and all meter selector switches to analog output. Turn system power - ON and check each channel using the same procedure as described in the bench tests. In this case, however, it will be necessary to have the satellite mounted in a manner that will enable each of the three axis to be tilted through horizontal and held there to within $\pm \frac{1}{2}$ degree. Perform the Command and

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Digital Signal Conditioner Tests as described in the Bench tests. Turn system power - OFF. Turn Test Set power - OFF. Remove Test Set Cable and disconnect power cord to test set. This completes installation tests. The system may now be connected to the various satellite systems by way of J5 on the signal conditioner.

V. SATELLITE TESTS

Connect the system to the satellite power, telemetry, and command systems by means of J5 on the signal conditioner. Apply power to the system and command both Sensitive and Cross Axis into Range A. Again the satellite must be horizontal to within $\frac{1}{2}$ degree. Perform the check of each channel as described in the bench tests. Perform the Command and Digital Signal Conditioner tests also as described in the bench tests. This time the voltages will have to be read at the output of the telemetry. This completes the satellite tests.

VI. CHANNEL REPLACEMENT

In the event a channel becomes defective either due to a faulty accelerometer or electronics, both units must be replaced. Remove the three axis instrument package, the defective channel electronics, and the interface unit from the satellite. All three packages, plus the associated W1 and W2 cables should be returned to the manufacturer (Bell Aerospace Company) for repair.

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OUTER SHIELD

18	18	PICK OFF EXCITATION	25	25
6	6	PICK OFF EXCITATION RET	13	13
16	16	PICK OFF SIGNAL	9	9
4	4	PICK OFF SIGNAL RET	5	5
5	5	ACCEL A	12	12
17	17	ACCEL B	7	7
9	9	SUSPENSION RET	8	8
21	21	SUSPENSION A	20	20
22	22	SUSPENSION B	21	21
3	3	ACCEL TIME MON RET	18	18
1	1	ACCEL TEMP MON	6	6
4	4	4 PULSES	4	4
25	25	6 PULSES	11	11
13	13	4 PULSES	10	10
24	24	16 PULSES	24	24
12	12	PULSE RET	23	23
11	11		22	22

19	19	SUSP
20	20	SUSP
21	21	SUSP
9	9	CON'ST
6	6	CONST
17	17	CONST
3	3	CMD
22	22	RO GAIN CMD
25	25	PICK OFF
13	13	OVER
24	24	ACCE
7	7	ELEC
14	14	6
4	4	6 P
15	15	6 PULSE
4	4	TELE
8	8	CNAB
1	1	+20
2	2	+28V
5	5	SUS
11	11	SA
2	2	
16	16	200AT R
10	10	ANA
23	23	16 SUSP

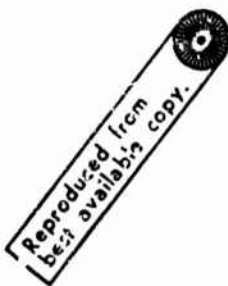
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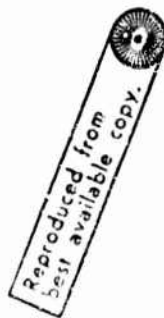
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REVISIONS		DATE	APPROVE
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3 RUN 20 WELLS BE "WELLS TO EXIST" COUNCIL - 17
DOWN WITH 10-11-12 AND 13-14-15-16-17-18-19-20
BE "WELLS TO EXIST" COUNCIL - 17
A LENGTH TO BE DETERMINED AT FIRST INSTALLATION
1. APPLICATION IN ACCORDANCE WITH 10-11-12-13-14-15-16-17-18-19
NOTES

900003-9/16

BELL AEROSYSTEMS COMPANY										SHEET	
POST OFFICE BOX ONE BUFFALO, NEW YORK 14200											
DIVISION OF BELL AIRCRAFT CORPORATION - A TEXASIN COMPANY											
OWN NAME AND NUMBER TO											
SP 17-16										246 70	
APVD BY										DATE	
WT										REV.	
CHK BY										DATE	
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BLISS											
CONTR											
SIZE										CODE IDENT NO	
C 80070										DRAWING NO	
SCALE										SHEET	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS											
F										R	
A										X	
ANGLES										± 0° 30'	
UNLESS OTHERWISE SPECIFIED											
BREATHER EDGES .015 MAX RAD											
DRY CAMPS											
DIMENSIONING IS PER											
DIALS											
MACHINE SURFACES											
HOLE TOLERANCES FACE ± AS SHOWN											
.013 TO .020										+ .004	
.040 TO .125										- .005	
.130 TO .250										- .006	
.251 TO .485										- .008	
.486 TO .750										- .010	
.751 TO .985										- .012	
986 AND LARGER										- .012	
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						HOLE TOLERANCES EXCEPT AS SHOWN		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS		DESIGN <u>7100-1A-1</u>		DRAWING NO. <u>7100-1A-1</u>	
						0.040 TO 0.120 + .004 - .000		R <u>1/2</u> ANGLES: ± 1° ± 30'		GROUP <u>1/2</u>		APPROX. DATE <u>1-25-69</u>	
						0.125 TO 0.250 + .005 - .000		UNLESS OTHERWISE SPECIFIED BREAK ALL SHARP EDGES APPROX. 0.015 R ON CHAMFER		WT		INTERFACE UNIT COIL	
						0.250 TO 0.500 + .008 - .000		MACHINED SURFACES EXCEPT AS NOTED ✓		CHECK <u>3</u> DIMENSIONS			
						0.500 TO 0.750 + .010 - .000		SUPERFACES 6/76-3000-0		STRESS			
						0.750 TO 0.900 + .012 - .000		SUPERSEDED BY		REL <u>1</u> PART <u>1</u> 1-25-69			
						0.900 AND LARGER ± .010				CONTRACT NO.			
DATE		6/76-3000-0		NEXT ASSY		NEXT ASSY		FINAL ASSY		DATE		CODE IDENT NO.	
APPLICATION		QTY REQD								D		80070	
										TITLE		6/76-3000-0	



15

[illegible]

3.63 MAX

3.31 REF

4.85

J2

J3

DBM25P NMB-1-A123 (J3)


DBM25S NMB-1-A123 (J2)

1

2

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				HOLE TOLERANCES EXCEPT AS SHOWN				UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS				DESIGN <u>R. H. H. 5-8-69</u> GROUP APPD <u>P. J. [Signature]</u> EGT CHECK <u>P. J. [Signature]</u> STRESS REL <u>[Signature]</u> CONTRACT NO				BILL ABRA SYSTEMS - A-100 FIRST OFFICE BLDG ONE BUFFALO, NEW YORK 10601			
				.040 TO .125 + .005 - .000 .130 TO .250 + .006 - .006 .251 TO .500 + .008 - .008 .500 TO .125 + .010 - .003 .750 TO .999 + .012 - .000 ONE AND LARGER + .010				X XY XYZ ANGLES + .1 + .03 + .010 + 0°30'				OUTLINE - ELECTRONICS PACKAGE, CRI II MESA							
				UNLESS OTHERWISE SPECIFIED BREAK ALL SHARP EDGES A PROX .015 R OR CHAMFER MACHINED SURFACES EXCEPT AS NOTED				SUPERSIDES SUPERSIDED BY				SIZE CODE IDENT NO. D 80070 6176-300100							
DATE DESIGN PART QTY REQD				1 6176-300100 CRI II DASH NEXT ASSY USED ON APPLICATION				1 NEXT ASSY QTY REQD				SCALE 1/1 SHEET 52							



1. DETERMINE IDEAL OFFICE MAXIMUM OUTLINE OF UNIT, UNLESS OTHERWISE SPECIFIED

NOTES

11.990

CHANNEL Y

372
 360 DIA THRU
 3 PLACES

C.G. OF INSTRUMENT PROOF MASS
 CHANNEL X Y Z Z

11.947
 11.927
 12.470

C.G. OF INSTRUMENT PROOF MASS
 CHANNEL Y

C.G. OF INSTRUMENT PROOF MASS
 CHANNEL Y

(REF) IN NO 1

1.082
 1.143

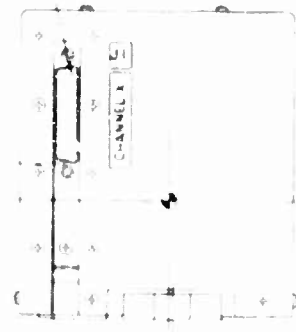
3.510
 3.490

CHANNEL X

CHANNEL X

4.40

450
 450
 3 PLACES



C.G. OF ASSY

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PARTS LIST				SPECIFICATIONS				REVISIONS			
QTY	DESCRIPTION	REF	QTY	DESCRIPTION	REF	QTY	DESCRIPTION	REF	QTY	DESCRIPTION	REF
1	BASE PLATE	1	1	BASE PLATE	1	1	BASE PLATE	1	1	BASE PLATE	1
1	PROOF MASS	1	1	PROOF MASS	1	1	PROOF MASS	1	1	PROOF MASS	1
1	CHANNEL X	1	1	CHANNEL X	1	1	CHANNEL X	1	1	CHANNEL X	1
1	CHANNEL Y	1	1	CHANNEL Y	1	1	CHANNEL Y	1	1	CHANNEL Y	1
1	ASSY	1	1	ASSY	1	1	ASSY	1	1	ASSY	1

REV	DATE	BY	CHKD	DESCRIPTION
1	11/2/66	J. J. Jones		INITIAL DESIGN

QTY	DESCRIPTION	REF	QTY	DESCRIPTION	REF
1	BASE PLATE	1	1	BASE PLATE	1
1	PROOF MASS	1	1	PROOF MASS	1
1	CHANNEL X	1	1	CHANNEL X	1
1	CHANNEL Y	1	1	CHANNEL Y	1
1	ASSY	1	1	ASSY	1

OUTLINE DRAWING
 2 AXIS ACCELEROMETER
 KWSA 22

162
 100070-1175-300-200